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(TITLE UNCLASSIFIED)
EVALUATION OF A HIGH-ENERGY BINDER

E. K. Ives
R. M. Kumagai
P. L. Allen
T. N. Scortia
United Technology Center

QUARTERLY REPORT AFRPL-TR-67-180
June 1967

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FOREWORD

(U) This is the first of three quarterly reports discussing the program UTC is conducting under Contract No. FO4611-67-C-0039 to evaluate PBEP, a high-energy NF_2 binder, in prototype propellant formulations. Experimental work conducted at UTC facilities during the period 1 March 1967 through 31 May 1967 is covered.

(U) Publication of this report does not constitute Air Force approval of the findings or conclusions presented herein. It is published only for the exchange and stimulation of ideas.

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ABSTRACT

(C) Work was continued on the formulation and sensitivity of AlH_3 propellants. Higher solids loadings of both AlH_3 and AP appear to give a less impact sensitive propellant than was obtained at the previously tested low solids loadings. It appears possible that a polyfunctional isocyanate such as CTI can replace the present cure system to avoid the use of hexanetriol as a cross-linker. Surveillance data show that the aluminized PBEP system with stabilizers can be stored at 35°C for long periods of time without significant deterioration. Lots of PBEP under cold storage for over 1 year can still be cured to give propellant with good tensile properties.

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ABBREVIATIONS AND SYMBOLS

Al	aluminum
AlH ₃	aluminum hydride
AP	ammonium perchlorate
Be	beryllium
BeH ₂	beryllium hydride
CTI	a triisocyanate from Aerojet-General Corporation
DBTDA	dibutyl tin diacetate
DBTDL	dibutyl tin dilaurate
DMM	3,3'-dimethyldiphenylmethane-4,4'-diisocyanate
FeAA	ferric acetylacetonate
HT	1,2,6-hexanetriol
Isonate 143L	a polyfunctional isocyanate from The Upjohn Company
JANAF	Joint Army-Navy-Air Force
NF	difluoramino group
N ₂ F ₄	tetrafluorohydrazine
PBEP	poly [1,2-bis(difluoramino)2,3-epoxy propane] (C)
TCP	tricresyl phosphate
TVOPA	1,2,3 tris [1,2-bis(difluoramino) vinoxyl propane] (C)

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SECTION I

INTRODUCTION

1. PROGRAM SCOPE

(C) Under Contract No. FO4611-67-C-0039, UTC is conducting a research program to evaluate a high-energy NF_2 binder in both metallized and non-metallized propellants oxidized by conventional and high-energy oxidizers. The purpose of the program is the extension of the utility of the PBEB binder with state-of-the-art fuels and advanced fuels to yield advanced propellants of high performance, high density, and high-performance efficiency. In addition to these objectives the program is designed to develop NF_2 propellants with a range of burning rates, to provide test data on the stability of NF_2 propellants, and to develop stabilizers for these same propellants.

(C) The program is divided into five phases. Phase I calls for the investigation of various cure systems and plasticizers to yield an optimum gumstock. The sensitivity and compatibility of PBEP with all possible combinations of all plasticizers, fuels, and oxidizers will be tested.

(C) Phase II calls for the formulation of the optimized binder from phase I with nontoxic fuels and both conventional and advanced oxidizers to approach a theoretical specific impulse goal of 300 sec (1,000 to 14.7 psia). The formulation developed under this phase will be tested physically, mechanically, and ballistically in 1-lb motors.

(C) Phase III calls for the formulation of the phase I optimized binder with toxic fuels and both conventional and advanced oxidizers to give propellants which approach a theoretical target specific impulse of 325 sec (1,000 to 14.7 psia). The formulations will be tested physically, mechanically, and ballistically in 1-lb motors.

(U) Phase IV calls for long term aging studies and temperature cycling studies on formulations from phases II and III.

(U) Phase V calls for the investigation methods for improving the thermal stability and decreasing the burning rates of PBEP formulations.

2. REPORT STATUS

(U) The present report covers the experimental work performed during the first quarter, 1 March 1967 to 31 May 1967. The reporting status for the program is presented graphically in figure 1.

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	1967												1968												1969													
	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F		
Monthly Letter Report				4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24														
Monthly Government - Furnished Propellant Report																																						
Quarterly Technical Report																																						
Final Technical Summary Report																																						

Figure 1. (U) Program Report Status

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SECTION II

TECHNICAL DISCUSSION

1. INTRODUCTION

(C) PBEP is prepared by Shell Chemical Company by the direct addition of N_2F_4 to the unsaturated carbon-to-carbon double bonds in dehydrochlorinated polyepichlorohydrin which has been glycerol initiated. PBEP is a tan-colored, highly viscous polymer with a typical molecular weight for the current material of 3,300 to 3,800.

(C) Formulation of PBEP propellants is accomplished by addition of a plasticizer to lower the viscosity of the prepolymer. The polymer is hydroxy-terminated and is cured with a diisocyanate such as DMM used in conjunction with a crosslinker such as 1,2,6-hexanetriol.

2. AlH_3 PROPELLANT STUDIES

(C) AlH_3 /PBEP propellants have been processed successfully in formulations with up to 73 wt-% solids loadings and containing 21% AlH_3 . This is a preliminary study leading to formulation and processing of propellants with even higher solids loadings that are necessary to obtain the maximum specific impulse in a feasible system. The propellants resulting from this study have been tested for mechanical and hazard properties.

a. Physical Property Data

(C) UTX-8462-1 and -2 listed in table I contained 21 wt-% AlH_3 and had a total solids loading of 73 wt %. This formulation has a theoretical specific impulse of 284 sec and a density of 0.062 lb/in.³ Crosshead physical property data from UTX-8462-1 was 200 psi tensile and 15% elongation. UTX-8462-2 gave crosshead data of 114 psi tensile and 6% elongation. UTX-8462-2 had a longer cure time than UTX-8462-1 accounting for the variation in physical properties between the two mixes.

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TABLE I
(U) AlH_3 FORMULATIONS

Formulation No.	UTX-8465-5	UTX-8465-6	UTX-8466-2	UTX-8466-3
PBEP (9557-99A)	14.43	14.43	12.13	12.13
TVOPA	14.43	14.43	12.13	12.13
DMM	2.33	2.33	1.96	1.96
HT	0.17	0.17	0.14	0.14
DBTDA	0.64	0.64	0.64	0.64
AlH_3	20.00	20.00	21.00	21.00
AP	48.00	48.00	52.00	52.00
Triol/PBEP(OH)	0.25	0.25	0.25	0.25
NCO/OH	0.86	0.86	0.86	0.86
Cure at ambient, days	5	5	5	5
Remarks	Partially cured	Partially cured	Soft cure	Soft cure

Formulation No.	UTX-8462-1	UTX-8462-2	UTX-8465-1
PBEP	12.13	12.13	14.43
TVOPA	12.13	12.14	14.43
DMM	2.20	2.20	2.33
HT	0.24	0.24	0.17
DBTDA	0.29	0.29	0.64
AlH_3	21.00	21.00	20.00
AP	52.00	52.00	48.00
Triol/PBEP(OH)	0.40	0.40	0.25
NCO/OH	0.86	0.86	0.86
Cure at ambient, days	10	10	10
Remarks	Cured	Cured	Cured

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b. AlH_3 Propellant Hazard Data

(C) Autoignition data listed in table II on propellant containing AlH_3 are similar to those obtained from propellant containing aluminum as a fuel with a 30-sec value of about 465°F and 10-sec value of 570°F. Spark sensitivity on this propellant was greater than 9.8 joules which is again similar to aluminum containing propellant. Friction sensitivity varies with occasional positive values obtained without added grit. Usually Pyrex grit is necessary for a positive test.

(C) The high impact values of 19.6 and 22.4 kg-cm obtained on UTX-8462-1 and UTX-8462-2 were obtained on humid days. Reruns on UTX-8462-2 on less humid days as well as on propellant retained in a desiccator until testing gave more realistic values of 12.6 to 14.9 kg-cm. Impact values on UTX-8465-4 and UTX-8466-2 varied from 6.0 to 7.8 kg-cm. UTX-8466-3 was very well cured and had an impact value of 12.0 kg-cm. Most of these values are much higher than values obtained previously on formulations with lower solids loadings. Apparently the added solids lowers the impact sensitivity as it does in formulations containing aluminum as the fuel.

c. Propellant Hazard Classification

(C) UTX-9838-1 listed in table II was cast for microcard gap specimens. These samples gave a card gap value of 1.30 in. Since the microtest gives a value about 0.1 in. above the standard JANAF card gap test, the actual value for this formulation is about 1.20 in. Card gap sensitivity of PBEP/ AlH_3 propellant (UTX-8405-5 and -6, table I) was 1.95 in. However, the cure of these samples are suspect and the high card gap values may be misleading. This same microtest system gave a value of 0.73 in. for a RH-C112cb formulation that normally has a value of about 0.63 in. from regular sized JANAF test specimens.

3. SURVEILLANCE STUDIES

(U) One of the primary research areas on PBEP as a high-energy binder for propellant systems is a study of its thermal stability during long term storage at elevated and ambient temperatures. This involves a surveillance study of basic formulations of various lots of PBEP and a study of possible stabilization additives. Three types of specimens are included in the surveillance program. One-lb motors are stored at 25°C and tested by firing

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TABLE II
(U) AlH_3 PROPELLANT HAZARD EVALUATION

Formulation No.	Impact kg-cm	Friction		Diamond Grit	Autoignition °F		Spark Sensitivity joules
		No Grit	Pyrex Grit		30 sec	10 sec	
UTX-8462-1	19.6	-	+	+	470	570	---
UTX-8462-2	22.4	-	+	+	465	585	>9.80
(1) Rerun	14.1	+	+	+	---	---	---
(2) Rerun	12.6	---	---	---	---	---	---
(3) Desiccated	14.9	---	---	---	---	---	---
UTX-8465-1	7.8	---	---	---	---	---	---
UTX-8465-6 Uncured	6.0	-	+	+	---	---	---
UTX-8465-4 Cured	7.8	---	---	---	---	---	---
UTX-8466-2							
(1) Uncured	7.6	-	+	+	---	---	>9.80
(2) 3 days ambient cure	7.8	+	+	+	---	---	---
UTX-8466-3 cured	12.0	-	+	+	---	---	---

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every 6 months. Two-in. cubes are stored at 35°C and tested by X-ray every 2 weeks for appearance of voids or cracks. Microtensile specimens maintained at both 25°C and 35°C are tested monthly for any change in mechanical properties.

a. Tensile Specimens

(U) Tensile specimen data listed in table III of formulation UTX-8430 containing PBEP lot 9557-99A and FeAA as cure catalyst were tested after storage at 35°C for 100 days. After 66 days the values were 17% elongation and 170 psi tensile and after 100 days storage 15% and 215 psi.

(U) UTX-8422 which contained PBEP lot 9557-84 and DBTDA as cure catalyst gave true physical property values of 30% elongation and 175 psi tensile after storage at 35°C for 7 months. Values after 6 months were 27% and 186 psi. This formulation also had tensile values of 195 psi and 27% after storage for 180 days at 25°C.

(U) Apparently no gross deterioration of the propellant has occurred after storage for 6 or 7 months at these temperatures.

TABLE III

(U) SURVEILLANCE TENSILE DATA

Formulation No.	Storage Time days	True Physical Property Data		Storage Temperature °C
		Tensile, psi	Elongation %	
UTX-8422	180	195	27	25
	180	186	27	35
	210	175	30	35
UTX-8430	45	230	18	35
	66	170	17	35
	100	215	15	35

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b. Two-in. Cubes

(U) Data for 2-in. propellant cubes in surveillance are listed in table IV. UTX-8423-1 which contained DBTDA and PBEP lot 9088-180 was unchanged after 132 days at 35°C but showed increased porosity when X-rayed at 172 days. UTX-8431-1 showed fissuring between 43 and 85 days. UTX-8430-8 and UTX-8430-7 were identical formulations except that the latter mix contains a 0.5% TCP. Apparently TCP does act as a stabilizer since UTX-8430-8 fissured between 43 and 85 days while the TCP-containing propellant has shown no change after 142 days. A cube of PPAA-3-111-2(A), a Rohm and Haas formulation, had some very small voids of 0.005 to 0.015 in. in diameter after 85 days but gave no further change after an additional 59 days at 35°C.

(C) Seven formulations listed in table V were cast as 2-in. cubes for surveillance studies. All cured very well except UTX-9841-1 which was mixed at too low a temperature due to loss of process water, and UTX-9843-1 which contained DBTDL as a catalyst. UTX-9841-2 was processed at a higher temperature than UTX-9841-1 and was well cured in 48 hours. UTX-9835-2, UTX-9836-2, and UTX-9841-1 had no stabilizers added but were prepared to evaluate different lots of PBEP in a basic formulation. UTX-9842-1 was similar except FeAA replaced DBTDA as cure catalyst to compare the relative stabilities of formulations containing the two catalysts. UTX-9839-1 contained 0.5% TCP as a stabilizer and UTX-9840-1 contained 0.5% TCP and 0.5% sulfur as additives. These cubes have been placed in surveillance storage along with the specimens currently being studied. Initial X-rays of these formulations showed no casting voids in any of the submitted cubes.

TABLE IV

(U) SURVEILLANCE DATA ON 2-IN. CUBES

Formulation No.	Storage Time Interval	PBEP Lot	Remarks
	days		
UTX-8423-1	132 to 172	9088-180	Contains DBTDA - gassed
PPAA-3-111-2(A)	142	---	No change
UTX-8431-1	43 to 85	9557-99A	Contains DBTDA - fissured
UTX-8430-8	43 to 85	9557-99A	Contains DBTDA - fissured
UTX-8430-7	142	9557-99A	Contains TCP - no change

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TABLE V
(U) SURVEILLANCE FORMULATIONS

Formulation No.	UTX-9835-2	UTX-9836-2	UTX-9839-1	UTX-9840-1	UTX-9841-1	UTX-9841-2	UTX-9842-1	UTX-9843-1
PBEP	17.76	17.76	17.68	17.68	17.68	17.68	17.68	17.68
PBEP lot	9237-163A	9557-14	9557-84	9557-84	9557-84	9557-84	9557-84	9557-84
TVOPA	17.76	17.76	17.68	17.68	17.68	17.68	17.68	17.68
HT	0.41	0.37	0.41	0.41	0.41	0.41	0.41	0.41
DMM	3.15	2.81	2.70	2.70	2.70	2.70	2.70	2.70
FeAA	---	---	---	---	---	---	0.64	---
DBTDA	0.64	0.64	0.64	0.64	0.64	0.64	---	0.64*
Al	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00
AP	46.28	46.66	46.39	45.89	46.89	46.89	46.89	46.89
TCP	---	---	0.50	0.50	---	---	---	0.50
S	---	---	---	0.50	---	---	---	---
Triol/PBEP(OH)	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
NCO/OH	1.00	1.00	0.86	0.86	0.86	0.86	0.86	0.86
Cure at 120°F, hours	72	72	72	160	96	48	160	144
Remarks	Cured	Cured	Cured	Cured	Uncured	Cured	Cured	Uncured

* The catalyst was DBTDL rather than DBTDA.

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c. Motor Firings

(U) A 1-lb motor firing of UTX-8422 formulation that had been stored at 25°C for 6 months gave a normal firing trace. However, the burning rate was somewhat higher than expected (1.52 in./sec at 585 psia).

4. ISOCYANATE STUDIES

(U) The commonly used crosslinker 1,2,6-hexanetriol, for the PBEP system has a much faster reaction rate with diisocyanates than PBEP. The product of this rapid reaction is immiscible with the PBEP-TVOPA binder resulting in propellant with long cure times or incomplete cures. This problem can be circumvented by changes in both formulation and processing, but it appears better to avoid the problem entirely. One possibility is the use of a polyfunctional isocyanate such as the proprietary triisocyanate, CTI, from Aerojet-General Corporation. Successful formulation of CTI would give the necessary crosslinking for obtaining propellant with good physical properties without the use of HT. CTI and other polyfunctional isocyanates are being investigated.

a. CTI

(U) CTI, a triisocyanate from Aerojet-General, has been evaluated in four 100-g mixes. Although the CTI is usually added as a mixture with TDI, this preliminary evaluation used CTI as the only curative in the formulations listed in table VI. UTX-9825-1 using PBEP lot 9557-99A and with an NCO/OH equivalents ratio of 0.86 cured gave specimens with a tensile of 50 psi and 37% elongation. UTX-9825-2 using lot 9557-84 and with an equivalents ratio of 1.24 also was well cured. The physical property data from the latter mix were 42 psi tensile and 27% elongation. The low stress values indicate either incomplete reaction or the occurrence of side reactions. CTI appears quite sensitive to moisture as indicated by the appearance of gassing if a slight excess curative is used.

(U) UTX-9828-1 with a low NCO/OH ratio of 0.60 did not cure. UTX-9832-1 with an NCO/OH ratio of 1.05 was well cured, but the tensile specimens were damaged during trimming and were discarded.

(U) UTX-9825-1 had an impact sensitivity of 36 kg-cm and autoignition values of 470°F at 30 sec, and 550°F at 10 sec. The impact value was much higher than a normal value of

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TABLE VI

(U) CTI FORMULATIONS

Formulation No.	UTX- 9825-1	UTX- 9825-2	UTX- 9828-1	UTX- 9832-1	UTX- 9834-1
PBEP	17.68	17.68	17.68	17.68	17.68
PBEP Lot	9557-99A	9557-84	9557-99A	9557-99A	9557-99A
TVOPA	17.68	17.68	17.68	17.68	17.68
CTI	1.14	1.14	0.79	1.05	0.53
DMM	---	---	---	---	1.06
DBTDA	0.64	0.64	0.64	0.64	0.64
AP	48.86	48.86	49.21	48.95	48.41
Al	14.00	14.00	14.00	14.00	14.00
NCO/OH	0.86	1.24	0.60	0.80	0.80
Cure at 120°F (hours)	144	168	240	120	144
Remarks	Cured	Cured	Uncured	Cured	Uncured

15 to 25 kg-cm but the autoignition values were similar to other propellants using DMM and HT.

(U) A mix of UTX-9834 was made with a mixture of CTI and DMM. This propellant failed to cure after 144 hours at 120°F. Additional mixes will be made to more completely evaluate CTI as a curative not only alone but in conjunction with DMM for the PBEP system.

b. Isonate 143L

(U) An isocyanate, Isonate 143L, manufactured by the Upjohn Company with a functionality of about 2.2 to 2.3 has been tested in gumstock samples without the use of triol. Adequate cures were obtained and this material will be tested in propellant mixes.

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c. DMM

(U) DMM, also prepared by the Upjohn Company, has been successful in propellant formulations without purification. Previously, the DMM used was an old lot made by DuPont that was purified by distillation. Since DMM is no longer available from DuPont, another source was necessary if this material were to be used. The Carwin Division of Upjohn has indicated that they are willing to produce this material. Their diisocyanate was found to be very satisfactory for well cured propellants.

5. HYDROXYL EQUIVALENT STUDIES

(U) There has been some indication that the hydroxyl equivalent values of PBEP have undergone a change during storage, even when stored at about 5°C. This fact is difficult to check since original equivalents values obtained either by IR or by gel time studies are only qualitative at best. Recently Esso Research and Engineering Company has published data in a report* indicating that IR gives a hydroxyl equivalent of 1.54 while a diborane method gave a value of 2.64. This latter number is 0.077 hydroxyl equivalents per 100 g of polymer and is very similar to values obtained by gel time studies which are usually between 0.070 and 0.080 hydroxyl equivalents per 100 g of polymer.

(U) Five lots of PBEP that had been stored for about 1-1/2 years at -5°C were evaluated for hydroxyl equivalents using CTI in gel time studies. Values obtained from these studies as compared to values obtained by IR are listed in table VII. As expected, the numbers obtained by gel time are not quite double those obtained by IR. Lot 9557-14 appears to be an exception since the gel number of 0.067 is somewhat less than might be expected from an IR value of 0.041 hydroxyl equivalents per 100 g of polymer. Propellant mixes listed in table VIII were prepared using these gel values.

(U) UTX-9826-1 utilizing PBEP lot 9557-84 required using lower cure equivalents than had previously been used. With a triol/PBEP(OH) of 0.70 and a NCO/OH ratio of 0.86, propellant was obtained that had true physical properties with a tensile of 113 psi and 53% elongation (table IX). UTX-9827-1 and -2 were formulations utilizing the lot of -84 with lower curative levels. UTX-9827-1 cured too rapidly to be cast successfully. UTX-9827-2 was cast but the tensile specimens were damaged during

* Hudson, B. E. and A. H. Muenker, "Functionality Determination of Binder Prepolymers," Quarterly Progress Report No. 2, 1 January - 31 March 1967, Contract No. F04611-67-6-0012, Esso Research and Engineering Company.

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TABLE VII

(U) HYDROXYL EQUIVALENTS STUDIES

<u>PBEB Lot</u>	<u>Hydroxyl per 100g Polymer</u>	
	<u>IR</u>	<u>Gel Time</u>
9557-84	---	0.075*
9237-163A	0.041	0.075
9088-180	0.041	0.075
9557-14	0.041	0.067
9237-86B	0.035	0.068

* Hydroxyl equivalent was not determined by IR for this lot of PBEP.

trimming and were discarded. UTX-9829-1 and UTX-9833-1 crazed somewhat on the surface during curing and were discarded. True physical properties of UTX-9835-1 containing lot 9237-163A were a tensile of 105 psi and elongation of 47%, and UTX-9837-1 containing lot 9237-86B with 104 psi tensile and 31% elongation indicating the hydroxyl equivalent values obtained by gel time studies were reasonably accurate. However, the gel value for lot 9557-14 in UTX-9836-1 apparently was too low since the propellant had a tensile of only 56 psi and an elongation of 40%. UTX-9836-1 and UTX-9837-1 after a month at ambient temperatures showed very little postcure giving a small increase in both tensile and elongation values.

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TABLE VIII

(U) FORMULATIONS FOR HYDROXYL EQUIVALENTS STUDIES

Formulation No.	UTX-9826-1	UTX-9827-1	UTX-9827-2	UTX-9829-1	UTX-9833-1	UTX-9835-1	UTX-9836-1	UTX-9837-1	UTX-9838-1
PBEP	17.68	17.68	17.68	17.68	17.68	17.76	17.76	17.83	17.76
PBEP Lot	9557-84	9557-84	9557-84	9088-180	9557-84	9237-163A	9557-14	9237-86B	9237-163A
TVOPA	17.68	17.68	17.68	17.68	17.68	17.76	17.76	17.83	17.76
DMM	2.70	2.27	2.27	3.13	3.17	0.41	2.81	2.86	3.15
HT	0.41	0.34	0.34	0.41	0.58	3.15	0.37	0.37	0.41
DBTDA	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64
AP	46.89	47.39	47.39	46.46	46.25	46.28	46.66	46.47	46.28
Al	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00
Triol/PBEP(OH)	0.70*	0.58*	0.58*	0.70*	1.00*	0.70*	0.70†	0.70†	0.70*
NCO/OH	0.86*	0.80*	0.80*	1.00*	0.86*	1.00*	1.00†	1.00†	1.00*
Cure at 120°F. hours	240	---	96	48	96	72	72	72	72
Remarks	Cured	Cured	Cured	Cured	Cured	Cured	Cured	Cured	Cured

* These numbers are based on 0.075 hydroxyl equivalents per 100 g of polymer.

† These numbers are based on 0.067 hydroxyl equivalents per 100 g of polymer.

‡ These numbers are based on 0.068 hydroxyl equivalents per 100 g of polymer.

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TABLE IX

(U) PHYSICAL PROPERTY DATA

<u>Formulation No.</u>	<u>PBEP Lot</u>	<u>True Physical Property Data</u>	
		<u>Tensile psi</u>	<u>Elongation %</u>
UTX-9826-1	9557-84	113	53
UTX-9835-1	9237-163A	105	47
UTX-9836-1	9557-14	56	40
UTX-9836-1 (1 month postcure)	---	66	42
UTX-9837-1	9237-86B	104	31
UTX-9837-1 (1 month postcure)	---	123	35

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SECTION III

CONCLUSIONS AND FUTURE WORK

(C) AlH_3 propellant containing higher solids loading appears less sensitive to impact than propellant with lower fuel and oxidizer loading. Even when the samples were dried in a desiccator the impact value was over 14 kg-cm. Perhaps, as in the aluminum system, additional AP may act as a diluent with correspondingly high impact values.

(U) It appears possible that a polyfunctional isocyanate could replace the current DMM-HT cure system. CTI and Isonate 143L both gave cures although gassing was noticed when the latter isocyanate was used. Other isocyanates will be tested as they are received.

(C) No gross deterioration was noticed in tensile specimens stored at 35°C for 8 months. The physical properties were still good with a tensile of 175 psi and elongation of 30%. TCP appears to be a possible stabilizer for the PBEP system. A formulation containing 0.5% TCP has survived at 35°C without any sign of gassing for about twice the period that an identical formulation with no TCP withstood. It appears that PBEP propellants with additives can undergo long term storage, at least at 35°C, within a minimum amount of deterioration. Other stabilizers than TCP will be tested.

(U) Several lots of PBEP that had been in cold storage longer than 1 year were retested for hydroxyl equivalents values and cure characteristics. Although the hydroxyl values appeared to have changed with time for some lots, the initial test for OH values is too inaccurate to draw any definite conclusions. All lots when formulated correctly gave well cured propellant with good physical properties.

(U) The facilities for small-scale cure and compatibility studies of Be and BeH_2 propellants have been completed and have been occupied. Installation and possibly checkout of remote mixing and firing facilities should be completed by the end of the next report period.

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13. ABSTRACT (UNCLASSIFIED) Work was continued on the formulation and sensitivity of LMH-1 propellants. Higher solid loadings of both LMH-1 and AP appear to give a less impact sensitive propellant than was obtained at the previously tested low solids loadings. It appears possible that a polyfunctional isocyanate such as CTI can replace the present cure system to avoid the use of hexanetriol as a cross-linker. Surveillance data show that the aluminized PBEP system with stabilizers can be stored at 35°C for long periods of time without significant deterioration. Lots of PBEP under cold storage for over 1 year can still be cured to give propellant with good tensile properties.			

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